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Specially Designed Multi-Functional Search And Rescue Robot

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Specially designed multi-functional search and rescue robot

Abstract. In digital era, robots are becoming an integral part of human life due to their efficiency and high performance. In recent years, search and rescue robot systems are used tremendously in a natural disaster. Nowadays, many areas of the world are getting affected due to natural disasters. Disasters can be exceptional and unstoppable events that are either man-made or natural, such as building collapse, earthquakes, wildfires, and floods, etc. This witnesses the importance of search and rescue robot systems in the emergency field. In the emergency field, a variety of sensing and wireless technologies are used in remote and vision control. The use of these technologies, the rescuers instead of going inside in the ruined area, can control remotely search and rescue robot systems when natural calamity occurs. These robot systems have the ability to move and monitor in the ruined area as a result of natural disasters such as building collapse, earthquakes, wildfires, and floods. In this paper, we design a sensor-based multi-functional search and rescue robot system for use in emergency situations. The system consists of an Arduino Mega board, Raspberry Pi 3 Model B+ board, servo motor, camera, Direct Current motor, motor driver module, stepper motor, Darlington Transistor Arrays, and ultrasonic sensor. The multi-functional search and rescue robot system has the ability to help the rescuers to search and show the ruined area from far away. The rescuers also could save their lives using this robot system. The main objective of this paper is to design a multi-functional, easy to control, microcontroller and Vision control based rescue robot system.

Keywords: Rescue Robot System, Sensors, Natural Disaster, Emergency.

Introduction

Modern technologies have rapidly changed every aspect of human life. Robotics technologies are one of the most developing modern technologies. Robotics technologies are used in many different fields (e.g., military, emergency, industry, medicine, etc.). The use of these technologies in the field emergency could provide efficient tools for achieving new solutions even under critical/difficult emergency conditions. In recent years, the rescue robot system has been one of the most used systems in the emergency field that are based on sensing and wireless technologies. The use of a rescue robot system in catastrophe situations is a revolutionary and interdisciplinary approach. During the last decades, several scientists have focused on the development of a variety of specialized systems that are used in natural disasters.

Research on rescue robot systems include automatic, mobile and remote systems. Reference [1] develops search and rescue robot system based on wireless sensor network. The system uses wireless ZigBee communication technology. Reference [2] develops a mobile rescue robot that could detect a human body in rescue operations of disaster. The system consists of four units: Microcontroller unit; Sensor unit; Robot driver unit; Transmission unit. Reference [3] designs and develops a search and rescue robot system equipped with a robotic arm that can be controlled by mobile devices. The system uses the Graphical User Interface (GUI) to ease users' utilization. Reference [4] designs and analyses a wheel-legged rescue robot. The designed wheel-legged rescue robot prototype is tested in real post-disaster environment. Reference [5] develops a method of automatically recognition of hazmat marking chart for rescue robot. The method can be used in detection and recognition in the real situation. Reference [6] uses both Arduino and Raspberry Pi as the main hardware component. Reference [7] develops an Android-based mobile robot for monitoring and surveillance. This mobile robot can be used for monitoring and surveillance purposes that may be strenuous for humans in some special cases. Reference [8] develops an optional passive/active transformable wheel-legged mobility concept for search and rescue robots. Reference [9] analyses the existing methods and concepts of rescue robotics. A variety of rescue robot types such as ground robots, aerial robots, marine and amphibious robots are surveyed in [9]. Reference [10] develops a model for behavior-based swarm robotic search and rescue by using a fuzzy controller. Reference [11] investigates an IoT-based human search and rescue robot by using swarm robotics. Sensors such as a GPS sensor for location tracker, an ultrasonic sensor for obstacle and edge detection for maneuvering purposes, and an LM35 temperature sensor are used in this work [11]. Reference [12] develops a wireless sensor network based rescue robotic system. The system uses an 8051 microcontroller which is developed to control the peripheral devices using the sensors such as passive infrared sensor, light-dependent resistor, and thermostat. Additional information addressing issues similar to previous ones can be found in [13]. Reference [13] designs and implements a remote controlled mobile rescue robot. The system a robotic system which is controlled by joystick, Xbee, gear motor servo motor and motor driver which are processed by Arduino UNO and Arduino MEGA Combination from a remote location in addition to remote monitoring using camera. Another interesting study (see [14]) designs and implements a LabVIEW based bore well child rescue robot. The robot uses ZigBee transmitter, micro-controller, robot arm and sensors to perform rescue operations. Reference [15] designs a sensor based rescue robot for catastrophe management. Reference [16] presents a new concept to handle the bore well rescue operations and designs a rescue robot. The robot is capable of moving inside the pipe according to user commands given from wireless communication. Reference [17] develops a prototype of search and rescue robot. The robot uses an Arduino board, an IR sensor, and a GPS sensor as a hardware component. Reference [18] presents an autonomous Unmanned Aerial System for life-saving services. The system's hardware and software analysis for design,

communication, navigation, and control requirements for a small hexacopter UAV are outlined. In [19] mine rescue robot systems are reviewed. Reference [20] proposes using mobile robots groups for rescue missions in extreme climatic conditions. Reference [21] designs and implements an alive human detection robot. The robot uses the ATMEGA16 microcontroller as a processor. Finally, [22] designs fire and rescue robot. The robot could detect the poisonous gas, the amount of the temperature inside the room.

Overall, the overview of previous contribution on search and rescue robot witnesses the tremendous attention devoted during the past decades to the development of various technology-based systems. However, none of aforementioned contributions ([1] - [22]) is likely to develop as multi-functionality as the proposed system developed in this work. We develop a specially designed multifunction search and rescue robot. The presented robot has the ability to detect metal. This prevents the explosion.

Main part

The proposed multi-functional search and rescue robot system uses the following sensors and modules:

- Servo motor
- USB camera
- DC motor
- Motor driver module
- Stepper motor
- Darlington Transistor Arrays
- Ultrasonic sensor
- Raspberry Pi 3 Model B+
- Arduino Mega

Servo motor

Servo motors are commonly used in robotics and several other applications. These motors are easy to control their rotation. Servo motors have a geared output shaft which can be electrically controlled to turn one degree at a time. In this system (multi-functional search and rescue robot system) 4 servo motors (SG90) are used.

Fig. 1. SG90 servo motor.

USB camera

Vision control are used for searching and rescuing process [23]. This system (multi-functional search and rescue robot system) uses the A4Tech PK-710MJ camera as a vision controller. The camera consists of a 5MP with a 10 cm focusing range that is capable of capturing still images as well as video. The module can capture at a resolution of 640 x 480 pixels, maximum frame 30 FPS. The camera uses USB 2.0 communication interface.

Fig. 2. A4Tech PK-710MJ

DC motor

A DC motor (Direct Current motor) is one of the most common types of motor that converts direct current electrical energy into mechanical energy. The most common DC motors rely on the forces produced by magnetic fields. DC motors have two leads, one positive and one negative. If these two leads are connected directly to a battery, the motor will rotate. If the two leads are switched, the motor will rotate in the opposite direction.

Fig. 3. DC motor

Motor driver module

In multi-functional search and rescue robot system are used different types of motors. The L298N Motor Driver Module is a high power motor driver for driving DC Motors and Stepper Motors. The module can control up to 4 DC motors, or 2 DC motors with directional and speed control. In this system the L298N Motor Driver Module is used for driving 4 DC motors. The module uses the popular L298 motor driver IC and has the onboard 5V regulator which can supply to an external circuit.

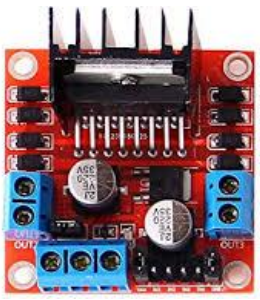

Fig. 4. L298N motor driver

Stepper motor

A stepper motor is one of the motor types which converts electrical pulses into discrete mechanical movements. The multi-functional search and rescue robot system uses the 28BYJ-48 as a stepper motor. The motor connects with the ULN2003A driver board. There is a built-in stepper library in the Arduino platform that allows us to control the 28BYJ-48 stepper motor with the ULN2003A driver board.

Fig. 5. Stepper motor

Darlington Transistor Arrays

ULN2003 is a relay driver that consists of a Darlington array IC. The driver combines seven open collectors Darlington pairs with the common emitter. The ULN2003A driver has the capability of handling seven different Relays at the same time. There are two bipolar transistors in a single Darlington pair. Darlington pair operates in the range of 500mA to 600mA current.

Fig. 6. Darlington Transistor Arrays

Ultrasonic Sensor

Ultrasonic sensors are transducers that convert ultrasonic waves to electrical signals or vice versa. Those that both transmit and receive these waves are called ultrasound transceivers. The functioning principle of these devices is similar to that of transducers used in radar and sonar systems, which evaluate attributes of a target by interpreting the echoes from radio or sound waves, respectively [24]. The multi-functional search and rescue robot system uses the HC-SR04 Ultrasonic sensor module. The module has the non-contact measurement function to measure at 2cm - 400cm, the ranging accuracy can reach to 3mm.

Fig. 7. Ultrasonic sensors

Raspberry Pi 3 Model B+

The Raspberry Pi 3 Model B+ is one of the popular boards in the Raspberry Pi 3 range. The board has a 64-bit quad-core processor that can run at 1.4GHz, dual-band 2.4GHz and 5GHz wireless LAN. The board supports another communication technology such as Bluetooth 4.2/BLE and Ethernet. The board is used to provide for communication between the multi-functional search and rescue robot system and camera.

Fig. 8. Raspberry Pi 3 Model B+

Arduino Mega

The Arduino Mega is physically larger than all the other Arduino boards [25, 26] and has significantly more digital and analog pins. The Mega uses a different type of processor that allows greater program size and more. The Arduino Mega 2560 is ATmega2560 microcontroller-based board. The board has 54 digital input/output pins, 16 analog inputs, and also includes different types of technologies such as 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator and a USB connection. The Arduino Mega has been used in this system (multi-functional search and rescue robot system) because it has a lot of digital pins, analog pins.

Fig. 9. Arduino Mega

By combining all the sensors, modules, and boards mentioned above is created a whole multi-functional search and rescue robot system. All sensors and modules except cameras are connected to the Arduino Mega. The Arduino Mega does not support USB cameras. Therefore, The Raspberry Pi 3 Model B+ board is used to connect two cameras in the system. Between the Arduino Mega and the Raspberry Pi 3 Model B+ UART interface protocol is used for serial communication. The system can perform detecting metal, searching humans in the ruined area and sending collected data to a web server. On the server-side, the website shows video streams in real-time. As a result of video streaming the rescuers control the system remotely in real-time. The proposed electronic scheme of the multi-functional search and rescue robot system is presented in Figure 10.

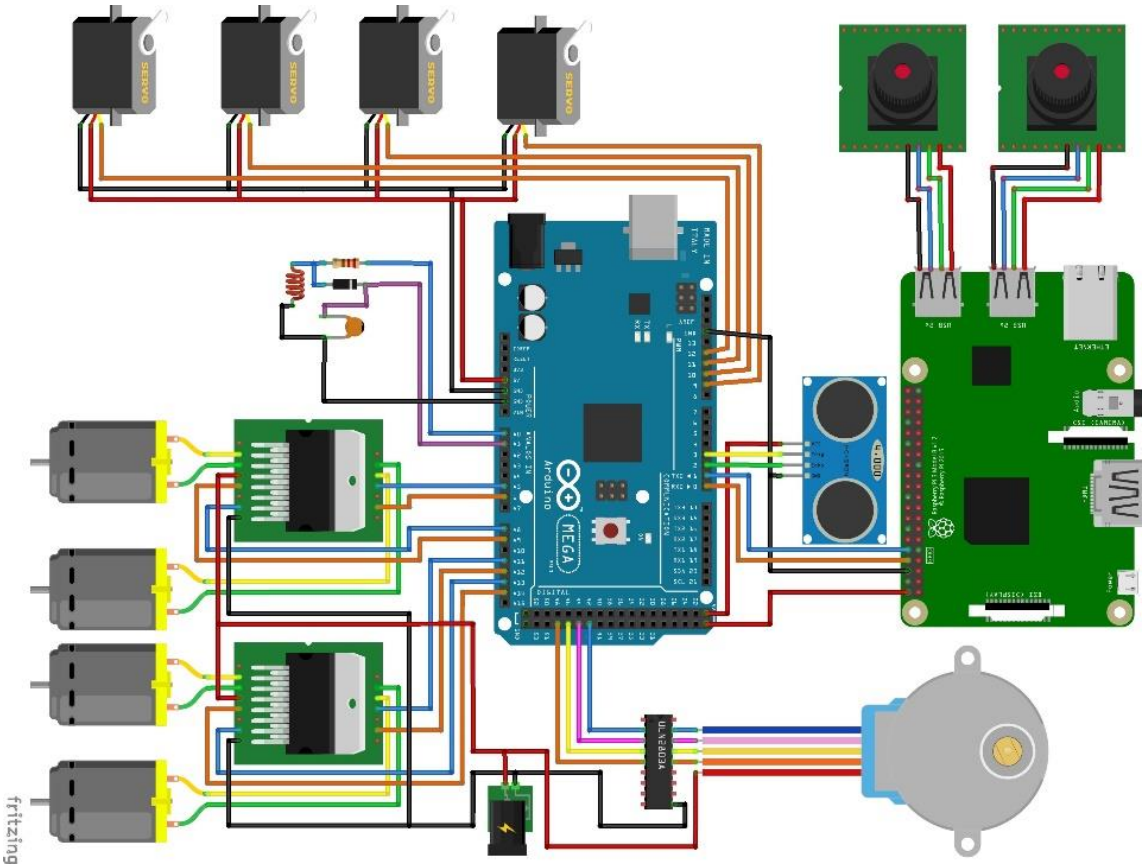

Fig. 10. The multi-functional search and rescue robot system model.

Conclusion

In this paper, a multi-functional search and rescue robot system based on Vision technology is developed. The system is likely to help the rescuers to detect hazardous substances and search human in the ruined area.

As ongoing work (outlook), the following issues are under investigation:

(1) Collection of data from the robot system with different states which are with action and without action;
(2) Quick analysis of the data from all sensors,
(3) Improvement of real-time performance.

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